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**The University of New Mexico  
Department of Electrical and Computer Engineering**

**FINAL SYMPOSIUM REPORT**

**“WORKSHOP AND PUBLICATION WORKING GROUP ON HIGH  
POWER MICROWAVE SOURCES AND TECHNOLOGIES”**

**AFOSR GRANT F49620-99-1-0087**

**Period of Performance: 1 January 1999 – 30 November 1999**

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**Report Dated: 22 February 2000**

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## ABSTRACT

A workshop was convened from June 3-12, 1999 at the University of New Mexico's Maui High Performance Computing Center. The purpose of the workshop was to bring together contributors to an IEEE Press Book entitled *Advances in High Power Microwave Sources and Technologies* in order to draft the initial manuscript. Workshop participants discussed competing ideas and converged on an initial draft. The scientific papers presented at the workshop thus comprise the book draft. Goals were then made for finalizing the book, having assigned tasks to each of the contributors. There will be 12 chapters describing recent advances in AFOSR-funded high power microwave research. Each chapter is led by a *Chapter Master* whose task is to coordinate the contributions from the chapter coauthors. In addition to this aspect of the workshop, technical sessions discussing the role of high performance computing on high power microwave tube design were also held. There were 29 registered attendees at the workshop.

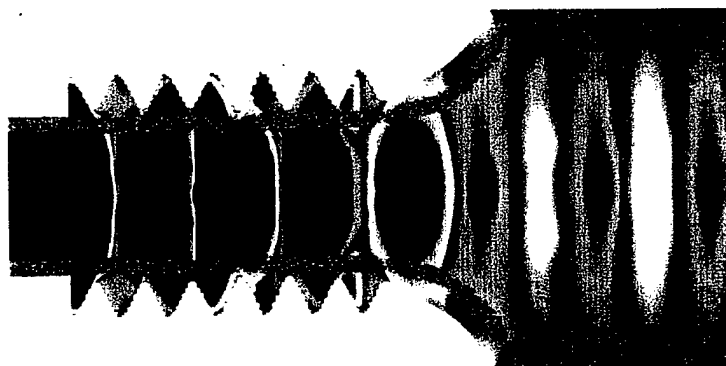
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## ***I. ADVANCES IN HIGH POWER MICROWAVE SOURCES AND TECHNOLOGIES***

Since the technical contributions to this workshop comprise a book draft that exceeds 500 pages, we only present here the Table of Contents and frontal material from the draft. Copies of the entire manuscript can be provided upon request.

# Advances in High Power Microwave Sources and Technologies



Edited by

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# Preface

This book presents a snapshot in time of the status of research on high peak power microwave (HPM) sources and technologies in the United States *circa* 1999. In particular, the focus of this book is on the results of high power narrowband source research that has been sponsored by, or closely aligned with the Department of Defense (DoD) Multidisciplinary University Research Initiative (MURI) to investigate novel high energy microwave sources. This MURI program officially came into existence in 1995. However, it builds on over a decade of microwave research efforts funded by the plasma physics office at the Air Force Office of Scientific Research (AFOSR) where one of us (RJB) is program manager. It is also synergistic with the ongoing Tri-Service Vacuum Electronics Initiative led by Robert Parker of the Naval Research Laboratory (NRL), as well as with AFOSR and the Air Force Research Laboratory-Rome Laboratory Site's long-standing Advanced Thermionic Research Initiative (ATRI).

Under the auspices of the MURI program, HPM scientists at nine U.S. universities have been attacking research projects under three Consortia led by Neville Luhmann at the University of California (Davis), Victor Granatstein at the University of Maryland (College Park), and Magne Kristiansen at Texas Tech University (Lubbock). The other university participants include the other Co-Editor (ES) at the University of New Mexico (Albuquerque), John Nation at Cornell University (Ithaca), Ned Birdsall at the University of California (Berkeley), George Caryotakis at Stanford University (Stanford Linear Accelerator Center), Ronald Gilgenbach at the University of Michigan (Ann Arbor), and Tony Lin at the University of California (Los Angeles). To facilitate the rapid transition of research results into the industrial community, formal collaborative subcontracts were established with James Benford (Microwave Sciences), Carter Armstrong (Northrop-Grumman), and Howard Jory (CPI). Furthermore, cooperative ties were strengthened with the ongoing HPM research and development efforts at the Air Force Research Laboratory-Phillips Research Site (Kirtland Air Force Base, NM) first under the leadership of Jack Agee, and later through the liaison efforts of John Gaudet.

This book presents a fair assessment of the state-of-the-art in HPM source research and associated technologies that are of relevance to the DoD. Following the introduction in Chapter 1, Chapter 2 presents HPM source research in the broad context of interest in the DoD on rf sources in general. Chap-

ters 3-6 present advances in HPM sources and a better understanding of the *pulse shortening* issue that has received a great deal of attention. Chapters 7-11 present advances in enabling technologies that are essential not only to achieve a better understanding of the physics of HPM sources, but also to make HPM practical. Finally, alternate approaches to achieving HPM, and future challenges in this nascent area of research, are presented in Chapter 12.

This book brings together contributions from each of the participants of, and affiliated research groups with the MURI program. The writing of each of the chapters was led by a *Chapter Master* whose responsibility was to not only coordinate the efforts of the coauthors, but to also follow the guidelines and notation put forth by the Co-Editors. To this end, we would like to express our deepest gratitude to each of the Chapter Masters: John Gaudet (Chapter 2), Kyle Hendricks (Chapter 3), Jim Benford (Chapter 4), John Nation (Chapter 5), Vic Granatstein (Chapter 6), Yuval Carmel (Chapter 7), Chaouki Abdallah (Chapter 8), Ryan Umstattd (Chapter 9), Andreas Neuber (Chapter 10), and John Luginsland (Chapter 11).

Finally, we thank our colleagues in the MURI program that have agreed to participate in this book project to archive the advances in the field of high power microwaves.

Robert J. Barker  
Edl Schamiloglu  
January 2000



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## **Appendix A – Workshop Invitation**

## **Appendix B – List of Attendees**

as of 6/10/99

# MURI REGISTRATION SPECIFICS

| First Name  | Last Name    | Registration | AM \$4 | Noon \$6 | WD \$20 | WDS \$30 | L \$30 | L S \$50 | L K \$28 | FD \$20 | FD S \$30 | Total Reg | Total Meals | Total Paid |
|-------------|--------------|--------------|--------|----------|---------|----------|--------|----------|----------|---------|-----------|-----------|-------------|------------|
| Chaouki     | Abdallah     | \$350.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$240.00    | \$590.00   |
| Forrest J.  | Agee         | \$400.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$400.00  | \$240.00    | \$640.00   |
| Moe J.      | Arman        | \$400.00     | 3      | 3        | 1       | 0        | 1      | 0        | 0        | 0       | 0         | \$400.00  | \$80.00     | \$480.00   |
| Robert      | Barker       | \$400.00     | 6      | 5        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$400.00  | \$234.00    | \$634.00   |
| James       | Benford      | \$350.00     | 5      | 5        | 1       | 1        | 1      | 1        | 0        | 0       | 0         | \$350.00  | \$180.00    | \$530.00   |
| Anna        | Brown        | paid         | 6      | 6        | 1       | 0        | 1      | 0        | 0        | 0       | 0         | \$0.00    | \$110.00    | \$110.00   |
| Yuval       | Carmel       | \$350.00     | 6      | 6        | 1       | 0        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$210.00    | \$560.00   |
| George      | Caryotakis   | \$350.00     | 6      | 6        | 1       | 0        | 1      | 1        | 2        | 1       | 1         | \$350.00  | \$266.00    | \$616.00   |
| Jim C.      | Dickens      | \$350.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$240.00    | \$590.00   |
| John        | Gaudet       | \$400.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$400.00  | \$240.00    | \$640.00   |
| Ron         | Gligenbach   | \$400.00     | 4      | 4        | 0       | 1        | 0      | 0        | 0        | 1       | 0         | \$400.00  | \$90.00     | \$490.00   |
| Victor      | Granatstein  | \$350.00     | 6      | 5        | 1       | 2        | 1      | 2        | 0        | 1       | 2         | \$350.00  | \$344.00    | \$694.00   |
| Frank       | Hegler       | \$350.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$240.00    | \$590.00   |
| Kyle        | Hendricks    | \$400.00     | 6      | 0        | 1       | 1        | 0      | 0        | 0        | 0       | 0         | \$400.00  | \$74.00     | \$474.00   |
| Verboncoeur | John P.      | \$350.00     | 0      | 2        | 1       | 0        | 0      | 0        | 0        | 0       | 0         | \$350.00  | \$32.00     | \$382.00   |
| Howard      | Jory         | \$350.00     | 4      | 3        | 0       | 0        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$164.00    | \$514.00   |
| Kris        | Kristansen   | \$350.00     | 5      | 5        | 0       | 0        | 1      | 0        | 0        | 0       | 0         | \$350.00  | \$80.00     | \$430.00   |
| Linda       | Larsh        | \$400.00     | 6      | 6        | 1       | 0        | 1      | 1        | 2        | 1       | 1         | \$400.00  | \$266.00    | \$666.00   |
| Y.Y.        | Lau          | \$350.00     | 6      | 6        | 1       | 0        | 1      | 0        | 0        | 1       | 0         | \$350.00  | \$130.00    | \$480.00   |
| John        | Luginsland   | \$400.00     | 6      | 0        | 1       | 0        | 1      | 1        | 0        | 0       | 0         | \$400.00  | \$124.00    | \$524.00   |
| Neville C.  | Luhmann, Jr. | \$400.00     | 2      | 2        | 0       | 0        | 0      | 0        | 0        | 1       | 0         | \$400.00  | \$40.00     | \$440.00   |
| Peter       | Mardahl      | paid         | 6      | 6        | 1       | 0        | 1      | 0        | 0        | 1       | 0         | \$0.00    | \$130.00    | \$130.00   |
| John        | Nation       | \$400.00     | 6      | 5        | 1       | 0        | 1      | 0        | 0        | 1       | 0         | \$400.00  | \$124.00    | \$524.00   |
| Andreas     | Neuber       | \$350.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$240.00    | \$590.00   |
| Gregory     | Nusinovich   | \$350.00     | 6      | 5        | 1       | 0        | 1      | 0        | 0        | 1       | 0         | \$350.00  | \$124.00    | \$474.00   |
| Levi        | Schacter     | \$400.00     | 5      | 5        | 1       | 0        | 1      | 0        | 0        | 0       | 0         | \$400.00  | \$100.00    | \$500.00   |
| Edi         | Schamiloglu  | \$350.00     | 6      | 6        | 1       | 1        | 1      | 1        | 0        | 1       | 1         | \$350.00  | \$240.00    | \$590.00   |
| Tom         | Spencer      | \$400.00     | 6      | 0        | 1       | 0        | 1      | 1        | 1        | 0       | 0         | \$400.00  | \$152.00    | \$552.00   |
| Ryan        | Umstattd     | \$400.00     | 6      | 6        | 0       | 0        | 1      | 0        | 0        | 1       | 0         | \$400.00  | \$110.00    | \$510.00   |

154 \$616.00 133 \$798.00 24 \$480.00 13 \$390.00 25 \$750.00 17 \$850.00 5 \$140.00 20 \$400.00 14 \$420.00 \$10,100.00 \$4,844.00 \$14,944.00

| KEY  |                           |
|------|---------------------------|
| AM   | Breakfast                 |
| Noon | Lunch                     |
| WD   | Welcome Dinner            |
| WDS  | Welcome Dinner for spouse |
| L    | Luu                       |
| LS   | Luu Spouse                |
| LK   | Luu Kids                  |
| FD   | Farewell Dinner           |
| FDS  | Farewell Dinner Spouse    |

Minus Support Staff Costs \$350.00  
Total \$14,594.00



## **Appendix C – Workshop Handouts**

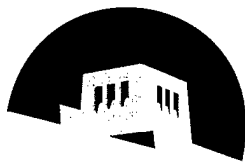
# Workshop & Publication Working Group

**Sponsored by,**

A circular stamp with a thick black border. Inside the circle, the text "MAUI - MURI - MAUI - MURI - HPM MURI-66" is written in a bold, sans-serif font, following the curve of the inner border. The text is arranged in a single line, with "MAUI - MURI - MAUI - MURI -" on the top half and "HPM MURI-66" on the bottom half. There is a small, dark, irregular mark in the center of the circle.



The University of New Mexico



The University of New Mexico

Department of Electrical and  
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Telephone (505) 277-2436  
FAX (505) 277-1439

## **HPM MURI 99 – Maui Workshop & Publication Working Group**

June 4, 1999

Dear Colleague:

On behalf of the workshop and publication working group organizing committee I would like to extend a warm welcome to you and your accompanying person(s) to Wailea, Maui. We are fortunate to have the opportunity to spend an extended period of time working on our book project in such a wonderful setting. I hope that you will find the island conducive to releasing your creative energy, as well as allowing you to interact with your fellow contributors.

I would like to thank AFOSR for its sponsorship of this workshop. I would also like to thank Microwave Sciences for its sponsorship of several of the functions associated with this workshop.

I would like to thank Candace Shirley at the MHPCC (UNM West) for her assistance in organizing this event and the reception at MHPCC.

I would like to thank the professional staff at the Outrigger Wailea for working so closely with the organizers in planning and executing this event.

I hope you enjoy working on the book, and I hope that you will have an opportunity to enjoy the island of Maui.

Edl Schamiloglu  
University of New Mexico

### **Organizing Committee**

R.J. Barker, AFOSR  
J. Benford, Microwave Sciences

J. Gaudet, AFRL  
C. Shirley, MHPCC

Major L. Larsh, AFOSR  
E. Schamiloglu, UNM

66-1480 MURI - HPM  
MAUI - MURI - MAUI

## LIST OF CHAPTER MASTERS

**Chapter Master: Edl Schamiloglu**

Chapter Master: John Gaudet

**Chapter Master: Kyle Hendricks**

Chapter Master: Jim Benford

**Chapter Master: John Nation**

**Chapter Master: Vic Granatstein**

## Chapter Master: Yuval Carmel

Chapter Master: Chaouki Abdallah

**Chapter Master: Ryan Umstattd**

Chapter Master: Andreas Neuber

Chapter Master: John Luginsland

To be compiled from input from Chapter Masters

# WORKSHOP AGENDA

## Thursday June 3, 1999

Workshop attendees arrive

## Friday June 4, 1999

### 8:00 AM-10:00 AM

Registration (*Outside Mauna Loa*)

Continental Breakfast (*South Pacific Lanai*)

### 10:00 AM-Noon

Opening Remarks, Overview of Workshop (*Mauna Loa*)

(Host, AFRL/AFOSR Representatives, AFRL/Phillips Site Representative)

### Noon-1:00 PM

Lunch for registrants (*South Pacific Lanai*)

### 1:00 PM-4:00 PM

Presentations by Chapter Masters (*Mauna Loa*)

(Note: There will be a coffee break at **2:30 PM**)

### 6:00 PM-7:00 PM

Cocktail Reception (*Makani*)

### 7:00 PM-9:00 PM

Welcome Dinner

## Saturday June 5, 1999

### Morning

Breakout sessions for each Chapter team (*Mauna Loa available all day*)

### Afternoon

Open

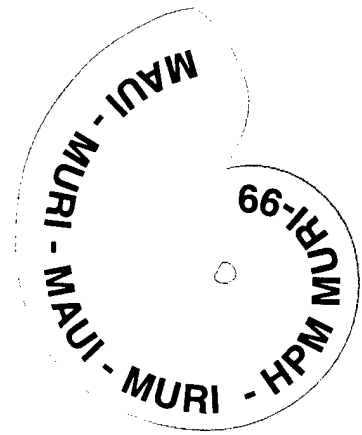
## Sunday June 6, 1999

### Morning

Open

### Afternoon

Breakout sessions for each Chapter team (*Mauna Loa available all day*)



## **Monday June 7, 1999**

**8:00 AM-9:00 AM**

Continental Breakfast (*South Pacific Lanai*)

**9:00 AM-Noon**

Attendees reconvene to discuss draft chapters (*breakout rooms indicated*)

**Noon-1:00 PM**

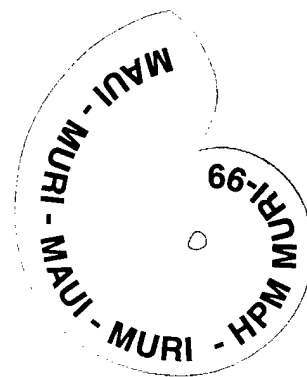
Lunch for registrants (*South Pacific Lanai*)

**2:30**

Bus arrives at hotel for tour of Maui High Performance Computing Center (MHPCC), demos, and reception.

**6:00**

Bus departs MHPCC for hotel.



## **Tuesday June 8, 1999**

**8:00 AM-9:00 AM**

Continental Breakfast (*Outside Makani Room*)

**9:00 AM-Noon**

Attendees reconvene to discuss draft chapters (*Makani*)

**Noon-1:00 PM**

Lunch for registrants (*Outside Makani Room*)

**1:00 PM-4:00 PM**

Attendees reconvene to discuss draft chapters (*Makani*)

(Note: There will be a coffee break at 2:30 PM)

**Evening**

Luau (*Workshop Banquet*)

## **Wednesday June 9, 1999**

**8:00 AM-9:00 AM**

Continental Breakfast (*South Pacific Lanai*)

**9:00 AM-Noon**

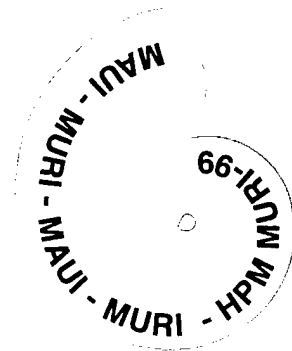
Attendees reconvene to discuss draft chapters (*breakout rooms indicated*)

**Noon-1:00 PM**

Lunch for registrants (*South Pacific Lanai*)

**1:00 PM-5:00 PM**

Attendees reconvene to discuss draft chapters (*breakout rooms indicated*)  
(Note: There will be a coffee break at 2:30 PM)



**Thursday June 10, 1999**

**8:00 AM-9:00 AM**

Continental Breakfast (*South Pacific Lanai*)

**9:00 AM-11:00 AM**

Panel Discussion - Role of High Performance Computing in HPM Source Design (*Mauna Loa*)

**Panel Members** Scientists from MHPCC, Scientists from AFRL/Phillips Site, University Representatives

**11:00 AM-Noon**

Continued discussions

**Noon-1:00 PM**

Lunch for registrants (*South Pacific Lanai*)

**1:00 PM-3:00 PM**

Attendees reconvene to discuss draft chapters (*breakout rooms indicated*)

**3:00 PM-5:00 PM**

Chapter Masters give report to workshop attendees (*Mauna Loa*)

(Note: There will be a coffee break at 2:30 PM)

**6:00 PM-7:00 PM**

Farewell Reception (*Pacific Terrace*)

**7:00 PM-9:00 PM**

Farewell Dinner (*Pacific Terrace*)

**Friday June 11, 1999**

**8:00 AM-9:00 AM**

Continental Breakfast (*South Pacific Lanai*)

**9:00 AM-Noon**

Wrap-up

**Noon-1:00 PM**

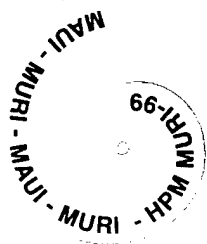
Lunch for registrants (*South Pacific Lanai*)

Adjourn

**Saturday June 12, 1999**

Departures

# **Advances in High Power Microwave Sources and Technologies**



**R.J. Barker and E. Schamiloglu, Editors**  
**IEEE Press**

## **REVIEWER REPORT TO CHAPTER MASTER**

**Chapter Number:**

**Your Name:**

**Date:**

1. Does this chapter follow the prescribed layout (Introduction, Overview of earlier work, Recent accomplishments-primarily MURI, but DO include other important advances)? If not, advise the chapter master which element is lacking.

2. Does this chapter read uniformly? What sections within this chapter appear to require considerable editing to achieve congruency? (Please make sure that the writing style is uniform. We decided to write using active voice-"we studied" as opposed to passive voice-"it was studied." Make sure active voice is used throughout.)

3. Is this chapter balanced? What sections appear to have either too little or too much emphasis compared with the rest of the chapter? Is there any superfluous material in this chapter not directly linked to the stated topic of this book?

4. Is the notation within the chapter uniform? Please assist the Chapter Master with establishing a notation list for this chapter.



5. A. Is there an important topic within this chapter that has been missed?

B. Is there an additional researcher who should be asked to contribute to this chapter? If so, please provide the Chapter Master with complete contact information.

6. Identify what sections within this chapter need to refer to other chapters in the book (make sure that there are appropriate "hooks"). (Example, to save on figure count, if the same figure is used in multiple chapters, use it in the first possible chapter, and let later chapters refer to that same figure.)

7. Is the reference list complete?

8. Please identify figures that are not of sufficient quality and would need to be reworked. Please identify problem explicitly (line widths too thick, font size of text too small, etc.)

9. Please provide any other comments regarding this chapter.



**Development Counsellors International** 461 Park Avenue South, New York, NY 10016  
Phone: (212) 725-0707 Fax: (212) 725-2254 E-mail: [millingworth@dc-intl.com](mailto:millingworth@dc-intl.com)/Website: [www.dc-intl.com](http://www.dc-intl.com)

Press Contacts: Montieth Illingworth, VP  
Melissa Hunter, AE  
Development Counsellors Int'l  
(212) 725-0707

**MHPCC Hosts DoD Multi-Disciplinary University Research Initiative Workshop**  
Scientists Focus on Advances in the Field of High Power Microwave Sources

**Maui, Hawaii -- June 28, 1999** – The Maui High Performance Computing Center (MHPCC) recently hosted a Multi-Disciplinary University Research Initiative (MURI) Workshop to examine the role of high performance computing in the design of high power microwave sources. MHPCC sponsored demonstrations showcasing the use of computer simulation in research and development to the group of 30 scientists from Department of Defense (DoD), academic, and commercial organizations.

MURI is a multi-agency DoD program chartered to accelerate the development of technologies that are critical to national defense and facilitate the rapid transition of research results into the industrial community. The purpose of the High Power Microwave MURI Workshop was to explore how high performance computing could be incorporated into on-going research efforts and review research materials for future publication. DoD researchers from the Air Force Office of Scientific Research (AFOSR) and the Air Force Research Laboratory (AFRL), private industry researchers from Communications and Power Industries and Microwave Sciences, and academic researchers from Cornell University, Stanford University, Texas Tech University, the University of California at Berkeley, the University of Maryland, the University of Michigan, and the University of New Mexico participated in the workshop.

AFOSR sponsors the High Power Microwave MURI in cooperation with AFRL, the Naval Research Laboratory (NRL), and the Army Research Laboratory (ARL). Research topics include increasing the efficiencies of microwave devices while reducing their weight and volume, analyzing and simulating higher energy microwave sources, and designing future microwave devices with higher output power.

A national resource, MHPCC is uniquely chartered to provide high performance computing technology resources to DoD, government, commercial, and academic users. MHPCC is a Distributed Center of the DoD High Performance Computing Modernization Program and a SuperNode of the National Computational Science Alliance, a National Science Foundation supercomputing initiative. MHPCC is a supercomputing center of the University of New Mexico, established in 1993 under a Cooperative Agreement with AFRL.

###